Remarks

Introduction

The claimed invention is directed to an improved cathode material for use in a secondary battery. The inventive cathode material contains (1) $LiFePO_4$; (2) one or more metal elements selected from the group consisting of vanadium (V), chromium (Cr), copper (Cu), zinc (Zn), indium (In), tin (Sn), molybdenum (Mo), and titanium (Ti); and (3) a halogen element. The respective amounts of constituents (2) and (3) are kept within a critical range.

Interview Summary

Applicants' attorneys wish to thank Examiner Weiner for her courtesy in discussing the Office Action by telephone with Attorney Ronald Goldstein on June 22, 2011. During that discussion, it was confirmed that that the Office Action is "non-final," and that paragraph 11 of the Office Action contains an erroneous statement in this regard.

Status of the Specification and Claims

The specification is amended herein, as requested by the Examiner during the June 22, 2011 telephone discussion, so as to move the sections titled "Industrial Applicability" and "Brief Description of Drawings" (i.e., paragraphs [0198] and [0199], along with their respective title captions) to their correct place in the specification.

Claims 1, 4-7, 9-10 and 14 were rejected in the Office Action. Claims 1, 4 and 6 are amended herein, and new claims 15-19 have been added.

The amendments to claims 1, 4 and 6 are as follows:

- The range of "n" in the cathode active material represented by the general formula Li_nFePO_4 has been amended to "$0 < n \leq 1$" – which is the correct range based on the

specification as originally filed. (The previous amendment of "n equals 1" was due to a misunderstanding by Applicants' attorneys.)

- The term "clement ratio" has been amended to "elemental ratio."
- For purposes of clarification, the amended claims now recite "wherein the upper limit of molar content of the halogen element is a molar concentration of twice that of the metal element or elements." Support for this amendment can be found in paragraph [0193] and Table 4 in the specification as originally filed. For example, paragraph [0193] states: "As for the upper limit of the halogen element content, it has been confirmed that cathode materials containing up to about twice the content of the foreign metal element exhibit similar characteristics."

New independent claims 15, 16 and 18 are analogous to claims 1, 4 and 6, respectively, but recite that the "halogen element is contained in an amount of 0.1 mol% to 1.45 mol% based on P." Thus, in these claims, not only the lower limit, but also the upper limit (1.45 mol%) of the halogen element content, is defined based on P. Support for this amendment can be found in paragraph [0193] of the specification as originally filed, which describes examples containing up to 1.45 mol% of a halogen element based on P.

New dependent claims 17 and 19 limit the halogen element to "chlorine." Support for this amendment is found throughout the specification as originally filed.

Thus, claims 1, 4-7, 9-10 and 14-19 are pending.

Response to the rejections under 35 U.S.C. 112

Claims 1, 4-7, 9-10, and 14 stand rejected under 35 U.S.C. 112, first paragraph, because the specification allegedly does not provide enablement for halogen elements other than chlorine. This rejection is respectfully traversed.

It is well known to those of ordinary skill in the art that halogen elements have common chemical properties with one another and often can be used interchangeably. Therefore, based on the specification's specific examples containing chlorine, one of ordinary skill in the art would be fully enabled to carry out the invention by using other halogen elements. Moreover, paragraph [0050] of the specification clearly describes the halides of halogen elements other than chlorine (e.g., F, Br, I), as follows:

> "[0050]
> Suitable examples of halides of molybdenum (Mo) include $MoCl_5$, $MoCl_3$, $MoBr_3$, MoI_2, and MoF_6. Suitable examples of halides of titanium (Ti) include $TiCl_4$, $TiCl_3$, $TiBr_4$, TiI_4, TiF_4 and TiF_3. Suitable examples of halides of vanadium (V) include VCl_3, VCl_4, VCl_2, VBr_3, VI_3, and VF_4. Suitable examples of halides of chromium (Cr) include $CrCl_3$, $CrCl_2$, $CrBr_3$, and CrF_3. Suitable examples of halides of copper (Cu) include $CuCl_2$, CuCl, $CuBr_2$, CuBr, CuI and CuF_2. Suitable examples of halides of zinc (Zn) include $ZnCl_2$, $ZnBr_2$, ZnI_2 and ZnF_2. Suitable examples of halides of indium (In) include $InCl_3$, $InCl_2$, InCl, $InBr_3$, InBr, InI_3, InI and InF_3. Suitable examples of halides of tin (Sn) include $SnCl_2$, $SnCl_4$, $SnBr_2$, $SnBr_4$, SnI_2, SnI_4, SnF_2 and SnF_4."

Claims 1, 4-7, 9-10, and 14 also stand rejected for indefiniteness under 35 U.S.C. 112, second paragraph since, according to the Examiner, (i) "there seems to be no upper limit to the range of the halogen element present"; (ii) "it is also unclear how a halogen element (H_y or H_{1-y}) can be present in an amount of 0.1 mol% or more based on P"; and (iii) "it is unclear how one or

more metal elements (M_x or M_{1-x}) can be present in a range of 0.1 to 5 mol% in terms of element ratio based on iron."

In response to the Examiner's concern identified in item (i) above, the claims have been amended to clarify that "the upper limit of molar content of the halogen element is a molar concentration of twice that of the metal element or elements."

In response to the Examiner's concern identified in item (ii) above, the Applicants acknowledge that it may seem unusual that the lower limit of the halogen content is defined based on P, while the upper limit is defined based on "the metal element or elements" (hereinafter, "M"). However, both elements (P and M) are present, in clearly defined and ascertainable amounts, in the claimed cathode material, which would allow one of ordinary skill in the art to discern clear upper and lower limits for the halogen content.

In response to the Examiner's concern identified in item (iii) above, it is respectfully urged that the claims clearly define both a lower limit and an upper limit for the content of the metal element M, based on iron in the cathode active material. The reasoning is as that the claims do not have any limitation whereby Fe decreases as M increases. The Fe content is fixed. Therefore, the recitation in the claims, that M is present "in the range of 0.1 to 5 mol%, in terms of elemental ratio, based on iron in the cathode active material," defines a clear-cut content range for M.

Thus, it is respectfully requested that the rejections under 35 U.S.C. 112 be withdrawn.

Response to the Rejections relating to the Drawings

In response to the Examiner's request during the June 22, 2011 telephone discussion with Attorney Goldstein, the Applicants have submitted a separate paper herewith, entitled "Remarks Clarifying Status of The Drawings." As was discussed with the Examiner, and as confirmed in the enclosed, separate paper, the rejections of the Drawings (as set forth in paragraph 5 of the Office Action), as well as the corresponding objection to the specification (as set forth in paragraph 6 of the Office Action), are in error. It is respectfully requested that these rejections/objections be withdrawn.

Response to the Art Rejections

Claims 1, 6 and 10 stand rejected under 35 U.S.C. 102(e) as being anticipated by Barker et al. U.S. Patent No. 6,777,132 ("Barker"). Claims 1, 4, 6 and 10 stand rejected under 35 U.S.C. 102(b) as anticipated by Barker or, in the alternative, under 35. U.S.C. 103(a) as obvious in view of Barker. Claims 1, 4-6, 9-10 and 14 stand rejected under 35. U.S.C. 103(a) as obvious in view of Barker in view of Ravet et al., U.S. Patent No. 6,855,273 ("Ravet"). These rejections are respectfully traversed.

The claimed invention contains critical limitations in terms of both the selection of certain metal constituents and the selection of ranges of concentrations of the metal and the halogen, which results in vastly improved performance of the resulting cathode material. As discussed below, the criticality of these selections is nowhere recognized in the cited art.

For example, the invention according to amended claim 1 requires the following:

(1) a cathode material for a secondary battery containing a cathode active material represented

by a general formula Li_nFePO_4 (wherein $0 < n \leq 1$) as a primary component;

(2) the cathode material contains one or more metal elements exclusively selected from the group consisting of vanadium (V), chromium (Cr), copper (Cu), zinc (Zn), indium (In), tin (Sn), molybdenum (Mo), and titanium (Ti);

(3) the total content of the metal elements is exclusively in the range of 0.1 to 5 mol%, in terms of elemental ratio, based on iron in the cathode active material; and

(4) the cathode material contains a halogen element in an amount of 0.1 mol% or more based on P, and wherein the upper limit of molar content of the halogen element is a molar concentration of twice that of the metal element or elements.

It is noteworthy that the invention of amended claim 1 is characterized in that:

(i) the cathode material **does not contain any metal element belonging to Group 7 to 10, such as Mn, Co, and Ni**, of the Periodic Table but contains exclusively the above-mentioned metal elements, with the total content of the metal elements exclusively in the range of 0.1 to 5 mol%, in terms of elemental ratio, based on iron in the cathode active material; and

(ii) **the halogen element is contained in an amount of 0.1 mol% or more based on P, and wherein the upper limit of molar content of the halogen element is a molar concentration of twice that of the metal element or elements**.

By requiring specifically selected metal elements with the content thereof in a specific, selected range, and by requiring a halogen element in a specific, selected amount, the cathode material of the present invention exhibits remarkably improved cycle characteristics in the

discharge capacity of the resulting secondary batteries, as described in relation to Examples 1 to 10 in the specification, and FIGs. 5 to 14 corresponding thereto.

The cathode materials of Reference Examples 1 to 5 in the specification, for which data are shown in FIGs. 5 to 14, contain the above-mentioned metal elements, but do not contain halogen. The cycle characteristics of these cathode materials containing no halogen deteriorate with the progress of the cycles, similarly to those of the cathode materials that don't contain the above-mentioned metal elements. By contrast, the cathode materials of Examples 1 to 10 in the specification, which do contain halogen, exhibit remarkably improved cycle characteristics, as clearly shown in Table 4, compared to those of cathode materials containing no halogen.

Moreover, Reference Figure 1 (which was submitted with the Amendment filed May 3, 2011 in this application) demonstrates the criticality of the fact that the present invention contains no metal elements belonging to Group 7 to 10 of the Periodic Table, such as Mn, Co, Ni, etc., but contains only the above-mentioned metal elements. As shown in Reference Figure 1, the cycle characteristics of the cathode materials containing Mn, Co, Ni or Mg (which would be encompassed within the cited art) deteriorate significantly, compared to those of the cathode materials containing the metal elements according to the present invention (Cu and Zn in Reference Figure 1).

Reference Figure 2 (which also was submitted with the May 3, 2011 Amendment) demonstrates the criticality of the fact that the the metal elements in the present invention are present exclusively in the range of 0.1 to 5 mol%, in terms of elemental ratio, based on iron in the cathode active material. The cathode material represented by the uppermost cycle characteristics line in Reference Figure 2 contains the metal Cu in a total amount of 1 mol%,

substituted for 0.5 mol% of Li and Fe, respectively. The other cycle characteristics lines represent cathode materials containing Cu in five times that amount, or in an amount of 5 mol%. It is shown that the initial discharge capacity deteriorates with a larger amount of Cu. For this reason, 5 mol% would be the upper limit. Incidentally, Reference Figures 1 and 2 also show the presence of halogen (chlorine) within the claimed critical range.

These critical features of the present invention, resulting in vastly improved performance characteristics, now will be compared with the disclosures of the cited art.

Barker merely discloses the use of "one or more metals, comprising at least one metal which is capable of undergoing oxidation to a higher valence state." (See, e.g., col. 3, lines 25-28.) This description applies to an extremely wide variety of metals, so as to include almost any metal. Moreover, Barker discloses Co, Mn, and Ni (which are excluded from the claimed invention) as preferred examples, and thus teaches away from the present invention. (See Barker at, e.g., col. 5, lines 59-64.) Furthermore, the content of these metals is disclosed by Barker as $1 \leq b \leq 3$ (see, e.g., col. 3, line 28); i.e, several orders of magnitude more than that of Applicants' claimed invention.

Thus, Barker discloses metal elements in such a manner as to make no distinction between the claimed metal elements and those (such as such as Mn, Co, and Ni that are included in Group 7 to 10) that actually would be destructive to Applicants' invention. Moreover, Barker discloses a very broad content range for the metal element – a range that goes well outside the critical range of the claimed invention, and that has been demonstrated to yield dramatically inferior results as compared to those obtained with the presently claimed invention.

Therefore, Barker fails to teach or suggest the technical significance of either the limited

kinds of metals contained in the claimed cathode material or the critical content range for these metals.

Further, although Barker discloses the use of halogen in his cathode material, the content of halogen is disclosed as $0<d\leq 6$ (see, e.g., col. 3, line 34) – several orders of magnitude more than the critical range claimed herein by Applicants. Moreover, Barker neither teaches nor suggests that, as claimed herein, the content of halogen element is based on the amount of phosphorus (P) and/or metal elements (M) in the active material.

The present invention also distinguishes patentably over Ravet, since Ravet similarly fails to recognize the criticality of the limited set of metal elements required in the present invention (i.e., one or more metal elements selected from the group consisting of vanadium (V), chromium (Cr), copper (Cu), zinc (Zn), indium (In), tin (Sn), molybdenum (Mo), and titanium (Ti)). Ravet further contains no description or suggestion that specifies the content of the metal element based on iron (Fe) in the cathode active material, much less any recognition of a critical content range. Additionally, Ravet only describes that halogen is contained as a substitute for oxygen atoms in PO_4 constituting the active material, and it does not describe or suggest the critical relationship between the content of halogen and the cycle characteristics.

Thus, Barker and Ravet, when considered either individually or together, neither teach nor suggest the cathode material of the present invention:

- which contains specific, selected metal elements (excluding, e.g., Mn, Co, Ni, etc.);
- wherein the metal elements are present in a specific, selected amount that is based on the amount of iron in the material; and

- wherein a halogen element is present in a specific, selected amount in relation to phosphorus (P) and metal elements (M) in the active material;

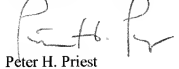
all of which are critical to the improved cycle characteristics in discharge capacity of the resulting secondary batteries.

Finally, since the remaining claims include every element of the above-discussed independent claim(s), the remaining claims also distinguish patentably over the cited art.

Conclusion

All of the presently pending claims, as amended, appearing to define over the applied references, withdrawal of the present rejection and prompt allowance are requested.

Respectfully submitted,



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